



Methodology to assess shelf life attributes of mountain pine beetle-killed trees

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Strategic importance

Sawmill operators in the central and northern interior of British Columbia (BC) are concerned about the negative impact of the increasing proportion of mountain pine beetle-killed trees on mill recovery and lumber value. Historically, most of these mills depended on a fibre supply of exceptionally high-quality green logs (i.e., trees that were alive when harvested). Consequently, logs were sound, lumber recovery was high, and recovery of high-grade visual and machine stress-rated (MSR) lumber was high.

During the initial stages of salvaging mountain pine beetle-killed trees over the last four years, there has been limited impact on sawmilling operations, as most salvaged trees have been in the green-attack stage. However, most future salvage will be red- and grey-attack stage trees. For sawmilling operations, the change may mean more breakage and waste in the mill, lower lumber recovery, and lower proportions of high lumber grade.

A study took place near Quesnel, BC, in November, 2004, to test a sampling procedure designed to determine which attributes of beetle-killed lodgepole pine trees resulted in a reduction in lumber recovery and product value over time. Old grey-attack trees were destructively sampled, and sampled trees, discs and logs were analyzed. The test results provided preliminary information on variables pertaining to log and wood quality and quantity of beetle-killed timber within older grey-attack stands.



Figure 1. Sample tree killed by mountain pine beetle.
Note complete loss of foliage.

Sampling procedures

Trees

Thirty lodgepole pine trees killed by mountain pine beetle were selected from six sites near Quesnel, BC. These trees represented the oldest beetle-killed trees readily accessible at the time of the study, and were estimated to have been dead for approximately four to five years (Figure 1).

Total height and diameter at breast height (1.3 m) were measured. Stage of attack and degree of degrade were determined by measuring proportion of bark intact at breast height, proportion of bark intact for the entire tree, foliage colour, proportion of foliage remaining, external check characteristics, and condition of small branches.

Discs

After the trees had been felled, stem analysis discs were cut at stump height (0.3 m above ground), at 2.5 m intervals thereafter, and at breast height (1.3 m above ground). Each disc was marked with the north azimuth, tree number, and disc height (Figure 2). Diameter (outside bark), bark thickness, and proportion of bark intact were measured.



Figure 2. Example of disc marks on tree 1, site 1 taken at 7.85 m above ground with checking observed in quadrants 1, 3 and 4.

The temperature was kept below 0° C while the trees were sampled and the discs transported: drying during handling and storage would have been minimal and would not have affected results significantly.

In the lab, check measurements included azimuth, depth, width, and pattern of each check. Moisture content was measured in the middle of the sapwood and the heartwood on each disc using a Delmhorst J-2000 moisture meter. Moisture estimates were reduced by 2% to account for differences with over-dry samples shown in lab tests. Blue stain measurements included the average width of blue stain, proportion of circumference stained, and whether the pattern was continuous or discontinuous. Decay by type (heartrot or saprot), and average width were also measured.

Logs

To simulate how these trees might be merchandized on the landing or in the mill, the data were analyzed in multiples of 2.5-m log lengths (2.5, 5.0, 15.0, and 20.0 m).

Moisture content of all 2.5-m log sections was computed as the volume-weighted average of the sapwood and heartwood.

The number of quadrants in each log with checks was computed using the azimuth of each check measured in the lab. These quadrants were consistent for all logs in the tree based on the north arrow marked on each stem analysis disc. The quadrants were defined as 1 (316° to 45°), 2 (46° to 135°), 3 (136° to 225°), and 4 (226° to 315°).

The sapwood area was estimated using the maximum depth of blue stain on the stem analysis discs.

The volume of each 2.5-m log was calculated using Smalian's formula with the diameter (inside bark) of the stem analysis disc at each end of the log. As there was almost no rot in these logs, there were no deductions for decay.

Results

Volume

The 30 trees had a total merchantable volume of 39.5 m³. Merchandizing to 2.5-m and 5-m logs provided slightly more volume than did 15-m and 20-m logs. Such results would not occur in operational settings as some waste and breakage would occur in the bush. The average piece size was 1.3 m³ and 1.1 m³ for the 20-m and 15-m logs. The large log size is also reflected in the average butt diameter of 41 cm for the 20-m logs, with an average top diameter of 18 cm.

Moisture content

Significant drying was found in all 30 sampled grey-attack trees (Table 1). The trees had dried to about 15% moisture content, significantly below fibre saturation point (about 30%). The moisture content was about 21% at the stump, fairly stable at about 16% for most of the bole, and then dropped to about 12% at the top.

The logs were not weighed, but their weight was estimated assuming a specific gravity for oven-dry lodgepole pine of 0.45, adding water weight, and not including bark. The overall average measured moisture content of 15% for the sample trees was used to estimate their weight, and, for comparison, an assumed moisture content of 70% was used for green logs. These approximations show a volume/weight conversion of 1.93 m³/tonne compared to the 1.31 m³/tonne for green wood (Table 2).

Checking

All trees had a significant number of deep checks present along the lengths of the trees (Table 3). Every tree and almost every log had at least one large check (> 2 cm in depth). Even when bucked into 2.5-m logs, 95% of the logs contained a large check.

Most of the largest checks were 8 cm to 12 cm deep (Figure 3). For butt logs (0 m to 5 m in height) and second logs (5 m to 10 m in height), 83% of checks were 8 cm to 12 cm deep. When considered by diameter (inside bark) of log tops (small-end diameter), most checks were 8 cm to 12 cm deep. Larger logs showed a higher proportion of checks in the deeper depth classes.

Table 1. Moisture content (%) of trees and logs.

Attribute	Tree Length	20 m Logs	15 m Logs	5 m Logs	2.5 m Logs
Number of Pieces	30	28	30	118	237
Sapwood					
Avg	15	15	15	15	14
Min	11	11	12	11	10
Max	20	20	20	21	23
Heartwood					
Avg	16	16	16	15	15
Min	12	12	12	11	10
Max	21	21	22	26	28
Total					
Avg	15	16	16	15	15
Min	12	12	12	11	11
Max	20	20	21	24	26

Table 2. Estimated load weight and scaling conversions. MC = Moisture Content

Attribute	Tree Length	20 m Logs	15 m Logs	5 m Logs	2.5 m Logs
Number of Pieces	30	28	30	118	237
Volume (m ³)	39.5	36.6	32.5	37.4	37.4
Oven-Dry Wood Weight (kg)	17,771	16,473	14,630	16,822	16,832
At 15% MC (dry sample trees)					
Water Weight (kg)	2,666	2,471	2,195	2,523	2,525
Total Weight (kg)	20,437	18,944	16,825	19,345	19,356
Conversion (m ³ /tonne)	1.93	1.93	1.93	1.93	1.93
At 70% MC (green trees)					
Water Weight (kg)	12,440	11,531	10,241	11,775	11,782
Total Weight (kg)	30,211	28,004	24,872	28,597	28,614
Conversion (m ³ /tonne)	1.31	1.31	1.31	1.31	1.31

Table 3. Proportion of logs with checks in 2 cm depth classes by log position and log small (top) end diameter (SED) inside bark.

	N	Maximum Check Depth (cm)							
		4	6	8	10	12	14	16	
Log Position									
1 (0-5 m)	30	7%	3%	37%	33%	13%	7%	0%	100%
2 (5-10 m)	30	7%	3%	20%	40%	23%	3%	3%	100%
3 (10-15 m)	30	3%	7%	13%	40%	27%	7%	3%	100%
Log SED									
15 cm	18	0%	17%	28%	39%	11%	6%	0%	100%
25 cm	45	9%	2%	18%	36%	29%	7%	0%	100%
35 cm	27	4%	0%	30%	41%	15%	4%	7%	100%

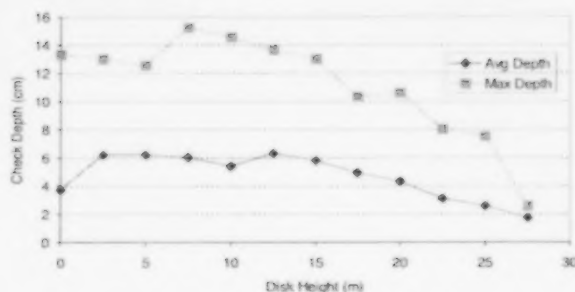


Figure 3. Average and maximum depth (absolute value) of checks by sample disc height.

Checking was extensively distributed around the circumferences of sampled logs. For example, checking was restricted to a single log quadrant in only 11% of the 5-m logs and 17% of the 2.5-m logs, whereas all logs of longer lengths had checks in more than one quadrant. For 15-m logs, 67% had at least one large check in each of the four quadrants, 23% had large checks in three quadrants, and only 10% had large checks in only one quadrant. For 2.5-m logs, 22% had large checks in all four quadrants, 30% in three quadrants, 31% in two quadrants, and 17% had at least one large check in only one quadrant.

Blue stain

Blue stain had occurred in all trees and logs. Overall, 34% of the 2.5-m log volume was blue stained (ranging from 7% to 70%). About 50% of the 2.5-m logs had 35% or more of their volume as blue stained wood. The proportion of blue stain increased up the trees, from about 30% in the lower bole to about 45% at the top.

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Conclusions

The results show significant drying and checking in the 30 sampled grey-attack trees. The trees had dried to about 15% moisture content, which is substantially below fibre saturation point, and had experienced significant checking. All trees had a significant amount of deep checks (> 2 cm in depth) present in all locations along the length of the tree, as well as distributed around the full circumference of the tree.

The procedures effectively measured a variety of characteristics related to the deterioration of wood quality in grey stage mountain pine beetle-killed lodgepole pine trees. The sampling procedures, if replicated at the operational level, would help to build models that predict the basic wood characteristics for individual trees related to the shelf life of beetle-killed wood. These models could then be applied at the stand level by compiling the estimates for the individual trees.

The predicted characteristics and subsequent analyses will support tactical and strategic planning on how to maximize the use and value of beetle-killed wood. These models could be used to assist in the harvest scheduling of individual stands in accordance with strategic operational planning objectives over large mountain pine beetle-killed areas.

Additional Reading:

- Lewis, K.J.; Hartley, Ian. 2005. Rate of deterioration, degrade and fall of trees killed by mountain pine beetle: A synthesis of the literature and experiential knowledge. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC. Mountain Pine Beetle Initiative Working Paper 2005-14. 21 p.
- Thrower, Jim; Willis, Rod; de Jong, Rene; Gilbert, Dave; Robertson, Hamish. 2004. Sample plan to measure tree characteristics related to the shelf life of mountain pine beetle-killed lodgepole pine trees in British Columbia. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC. Mountain Pine Beetle Initiative Working Paper 2005-1. 17 p.